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A SURVEY OF CANADIAN FABRICATORS TO DETERMINE THE NEED FOR ALUMINUM WELDING RESEARCH

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ABSTRACT

In an attempt to determine what aluminum welding research at the Industrial Materials Research Institute or other national research laboratories could overcome problems which are having a negative effect on the greater use of aluminum in transportation applications, a survey was made of 29 Canadian fabricators. They were selected to represent prinicipal road, rail and marine producers from coast to coast. A questionnaire was prepared to inquire as to their major welding problems and also where they find most help when a problem arises and how much they know about existing attempts to improve aluminum welding technology through research. The survey found a need for improving the understanding by industry of the role that research can have in solving their problems and in giving competitive advantage. It provided no suggestions that could presently justify an R&D programme at IMRI. However, the companies expressed a willingness for a closer relationship with IMRI which could eventually result in some mutually agreed research programmes.

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INTRODUCTION

The effective use of light metals (specifically aluminum) is important to Canada's transportation industry both for energy conservation and for lower maintenance and longer life. In rail, road and water transportation light weight reduces fuel consumption. Greater corrosion resistance reduces metal thickness loss. In electrical conductors for rail electrification light weight combined with high conductivity increases efficiency. For these applications much of the industrial world is exploiting the advantages of aluminum. Canada on the other hand while having some notable achievements, e.g., 2400 rail cars for grain built in the 1970's, a large number of fishing vessels built on the west coast over the past 20 years, the LRC passenger trains now used by VIA on their heavy traffic routes and large fleets of truck and truck trailer tankers, flat beds and dump bodies, is now finding that it is falling behind other nations in using aluminum for transportation applications. Whether or not welding problems are a major factor in this trend there continues to be a feeling that many fabricators are wary of tackling new products in aluminum because of real or imagined welding difficulties. Consequently a survey was proposed of selected aluminum fabricators to determine as accurately as possible what problems exist and what research would be needed to solve them and to ensure that the maximum advantage would be taken of aluminum's unique properties by Canadian industry.

THE SURVEY PLAN

The survey was limited mainly to fabricators working in the transportation field and covered the road, rail and marine sectors. Road transportation is naturally divided into automobiles and trucks so these have been treated as separate categories. As much as practical fabricators were selected from all geographical areas of Canada. While a number of agencies were suggested who could help select the fabricators to survey, in fact the major assistance in this regard came from the regional offices of the Canadian Welding Bureau. This organization is most aware of which companies are active users of aluminum welding because they either have certified them or are endeavouring to certify them to the CSA Standard W47.2- Certification of Companies for Fusion Welding of Aluminum. The regional CWB offices in Halifax, Montreal, Toronto, Winnipeg, Edmonton and Vancouver provided lists of potential candidates. Supplementing these with input from other sources a final list of 29 candidates was selected.

THE FABRICATORS

Each of the fabricators was phoned to get their agreement to participate in the survey and to set appointments for the visits. All not only agreed to participate but also showed enthusiasm and appreciation for the opportunity to expose their opinions. They were provided with a copy of the questionnaire beforehand to help prepare for the visit. Appendix A lists the companies that were visited. It should be noted that all are privately owned companies.

THE QUESTIONNAIRE

In preparing the questionnaire an effort was made to obtain as much information as possible within a reasonable visit length, i.e., not longer than 2 hours. Three drafts were necessary before a satisfactory format was achieved. The final questionnaire is found in Appendix B. Questions 1.1 to 5.5 were selected to give a picture of the fabricator and his operations. For example question 1.5 was meant to define in which industry group they should be placed and question 1.6 asked how many welders they employ and how many of them are qualified for aluminum to determine the size of their overall operations and their aluminum operations without having to ask impertinent questions about their finances. For those questions requiring opinion or judgment answers (6.1 to 11.9) it was soon found that some range of intensity in the answer had to be taken into account and thus the 0-10 ranges. An early draft of the questionnaire was "dry run" at Indal Technologies in Mississauga and their answers were reviewed after the final draft had been approved by IMRI.

THE SURVEY EXECUTION

The visits to the fabricators proved to be stimulating experiences. The time required to complete the questionnaires varied widely depending on how much discussion each question generated. Often the questions were not well understood because of the fabricator's limited contact with the area of technology or activity. In those instances explanation and illustration helped ensure that their responses to the questionnaire were realistic. There seemed to be little difficulty understanding the importance of the intensity ratings to their answers. Some were inclined to be more

conservative in their answer ratings than others but this was expected and does not invalidate the results or the general conclusions which can be drawn from them.

THE RESULTS

The survey results have been assembled in appendices. Appendix C records responses to questions 1.6 to 5.5. Tables 1-6 in Appendix D record responses to questions 6.0 through 11.0.

ANALYSIS OF RESULTS

Figures 1-10 are bargraphs displaying the data from Tables 1-6 of Appendix D. The bar lengths are shown as percentages of the maximum possible response points for each question, i.e., 29 companies x 10 = 290. This permits comparing responses between questions as well as reading directly the total response to each question.

Figure 1. It is obvious that industry feels closest to their welding equipment suppliers when it comes to needing help with welding problems. This is not too surprising when it is considered that often the problems are equipment related. Also they tend to see the equipment representatives from time to time which builds a natural relationship. The same is true to some extent with the metal suppliers and they are the natural resources for metallurgical information. The Welding Institute of Canada is also a natural contact for those who are members. Reference to universities for welding information is limited to those who already have a contact with someone at that university. The other resource organizations are mostly unknown to the fabricating industry and therefore received very low response.

Figure 2. The results in this graph need very little comment. As mentioned above those holding memberships in the Welding Institute of Canada are obviously aware of it and some of its activities but otherwise Canadian industry seems almost oblivious to the welding research institutions in our country. The following two graphs look at this situation by industry and by region. The bars represent response averages.

Figure 3. There is probably no significant difference in these responses. While the automotive industry appears to be slightly more aware than the others it should be remembered that only two automotive companies were surveyed.

Figure 4. This graph suggests two conclusions. First, the farther from central Canada the company is located the less likely it is to know about the organizations doing welding research. Second, Quebec has a significantly higher awareness of such organizations for some unexplained reason.

Figure 5. This graph explains what was said above in that the companies surveyed are unaware of research organizations because they have so little contact with them. Questions 8.6, 8.7 and 8.8 asked why so little contact, would they favour more and who should initiate it. Almost without exception they responded that no one from the organizations has ever approached them. They believe they would benefit from occasional contact but it would have to be initiated by the research organization. Only through research bulletins are they receiving any information on new developments and even at that they are probably not reading and following up on the information.

Figure 6. Eight programmes or facilities relating to the research into aluminum welding were presented for their response. This graph shows very low responses. Even the frequency modulated pulse power source developed at

WIC which has been the subject of presentations at welding conferences received only a 17% response. This speaks of the general ignorance of welding research in Canadian industry. As with the awareness of research organizations these results have been broken down by industry and by region in the following two graphs.

Figure 7. These results were difficult to accept until it was realized that the railway car, marine and general responses are likely statistically similar (only two rail car fabricators were surveyed) and the very low values for the truck and automotive can probably be explained. Aluminum for truck bodies, their designs and their manufacture have become so accepted as industry norms that new welding technology is not seen by the industry in general as a necessity. The automotive industry in Canada is largely engineered from the United States. For this reason a suggestion was made that the survey should include visits to the engineering departments of the three major automobile companies in Detroit but this did not seem to be in the scope of the programme.

Figure 8. Little can be said to explain these results except that only two companies in Saskatchewan were surveyed and both of them are truck body builders which might account for the missing bar. That the Quebec bar is the longest could result from the fact that the research programmes selected for the questions are mostly from Quebec or nearby. This does not explain the British Columbia response. However note should be made of the very low responses from all regions.

Figure 9. The 16 problem areas shown in this graph obviously overlap each other in many respects but it gives some idea of the types of problems facing users of aluminum welding. It is quite evident that maintaining satisfactory weld quality is a general problem and that porosity, workmanship

and weld appearance are major factors. It is also evident that welding equipment problems including the feeding systems for MIG electrode are a continuing concern. Distortion is also a factor but not given as much importance as expected. There was response to the question concerning metal preparation for welding in that many felt that no method has been yet defined which is both effective and also safe in all respects. Joint design was seen as an occasional frustration in that allowance is often not taken for the requirements of aluminum welding and especially in terms of access for the welding gun while retaining visibility of the joint for the welder. The other areas such as jigging, cracking, specifications, costs, metallurgy, corrosion, etc. seem not to be viewed as very serious. In summary only weld quality and welding equipment received responses approaching 50% but other factors are important to many of the fabricators and all except weld corrosion can be said to represent significant problems at some time or other.

Figure 10. The responses displayed in this graph might be considered somewhat fanciful because many of the companies have no experience in the technologies referred to. Also they were not committing themselves to anything. Consequently it is probably wise to make comparisons between technologies rather than placing too much importance in the absolute responses. Automation (which for most fabricators means some form of machine welding, not necessarily fully automated welding) is seen as an area of importance to their future ability to compete in lowering costs and in improving weld quality. However much of the technology already exists and waits for application to their particular operations. The questions on pre-qualified joints and procedures produced little response until they were given a vision of possible industry standards in these areas. These could then be used

without further qualifying which is at present a costly factor in certifying to the CWB. This possibility was seen as worthwhile by many of the fabricators.

The final question (#11.9) was added to elicit proposals for other areas of aluminum welding technology needing research. About one half of the companies responded and their suggestions have been summarized in Appendix E.

OBSERVATIONS

Canadian fabricators appear to have a pragmatic approach to welding, i.e. whatever works becomes standard practice. They perceive welding as a necessary tool but wish it were more like a machine tool which once purchased, installed and operating smoothly can be largely forgotten. The need for more or less continuous supervision to ensure maintenance of acceptable weld quality is a source of cost and frustration. This is evident from their interest in automating which they see as a means of controlling weld quality rather than increasing productivity or reducing cost.

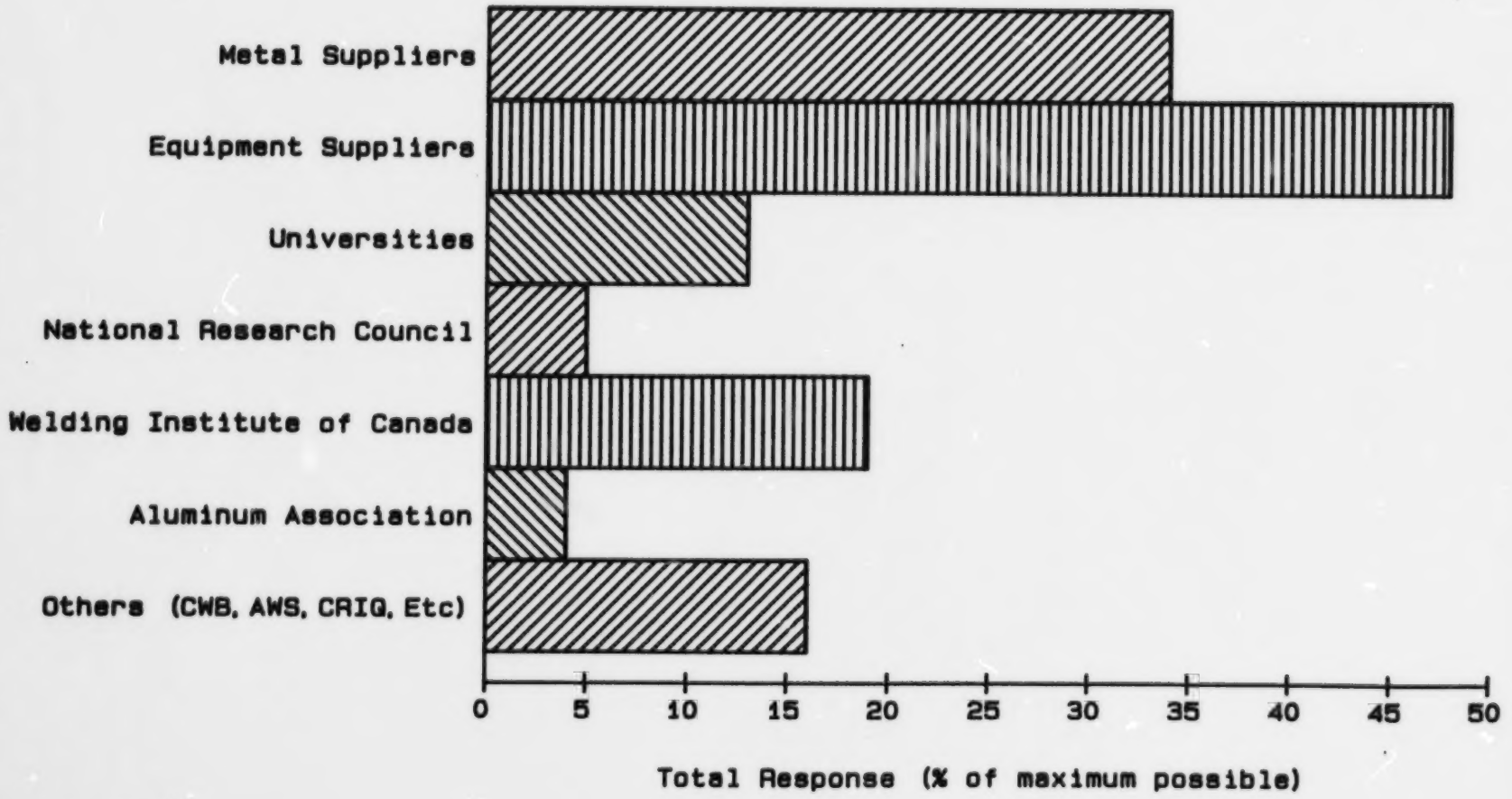
With one possible exception all their suggestions for welding research focus on improving their ability to apply what they are already doing. This appears to reflect a lack of commitment by their management to apply new welding technology in their operations. On the other hand national research organizations, e.g., IMRI or WIC, working at the leading edge of technology, are trying to maintain the same technology level as their peers in the more advanced technology countries. To do this they employ a much different level of personnel than their industrial counterparts. This has created a gap between them thus inhibiting communication and transfer of technology.

However, the industry seems open to the possibility of a closer relationship with IMRI. Properly managed such a relationship could eventually result in some mutually agreed research programmes but the initiative will have to come from IMRI.

CONCLUSIONS

The survey failed to identify any significant welding problems or companies interested at this time in participating in an R&D programme at IMRI. This is attributed to the fact that the aluminum fabricating industry in Canada is not technically innovative and does not understand the potential for advanced technology to give it the competitive edge. The industry is, however, prepared to have a closer relationship with IMRI which could eventually result in some mutually agreed research programmes.

Fig.1 - Organizations Contacted for Welding Information



TB/CT-REG.B21615-1

Fig.2 - Awareness of Welding Research Organizations

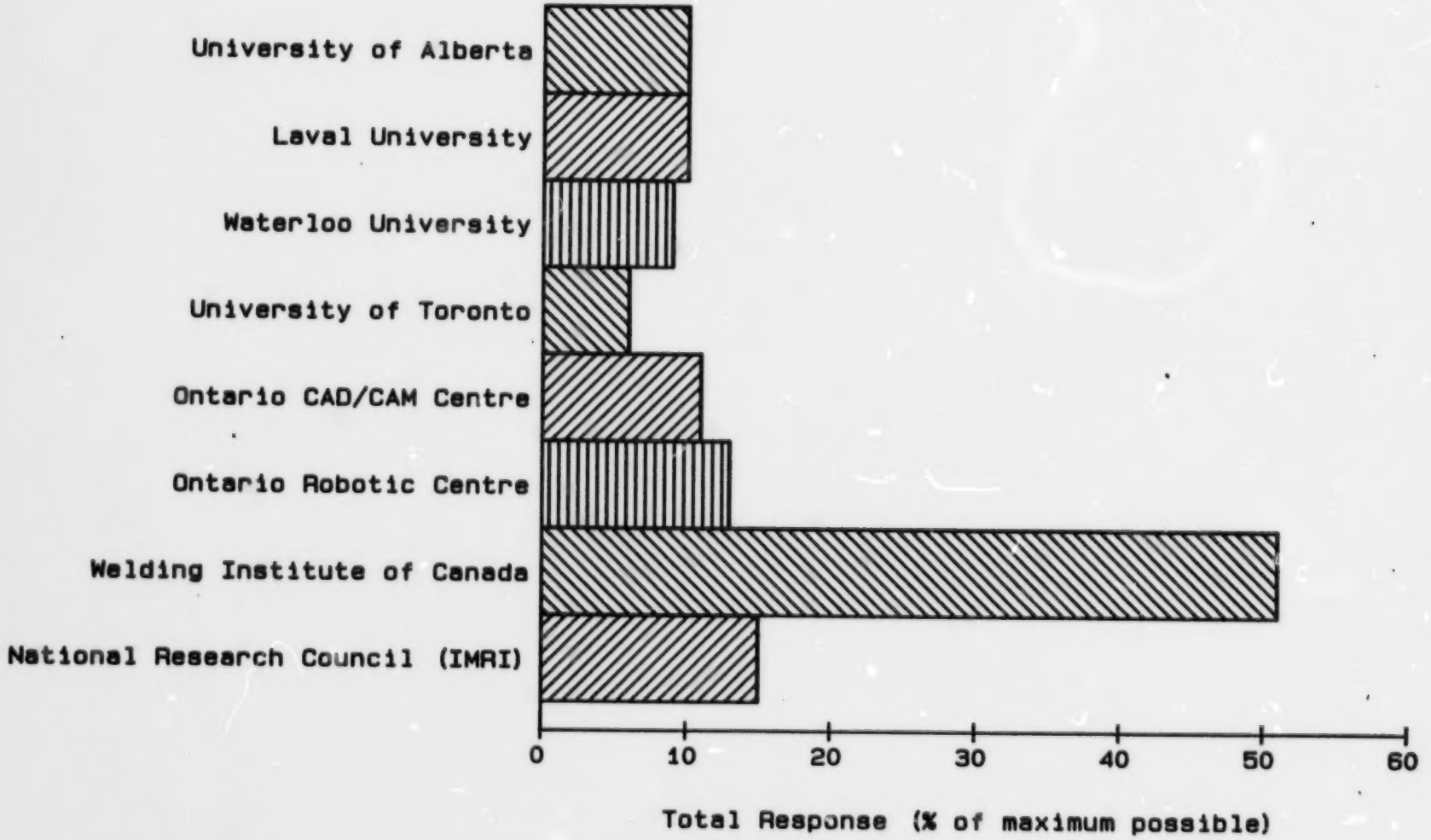


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Fig.3 - Awareness of Welding Research Organizations (by industry)

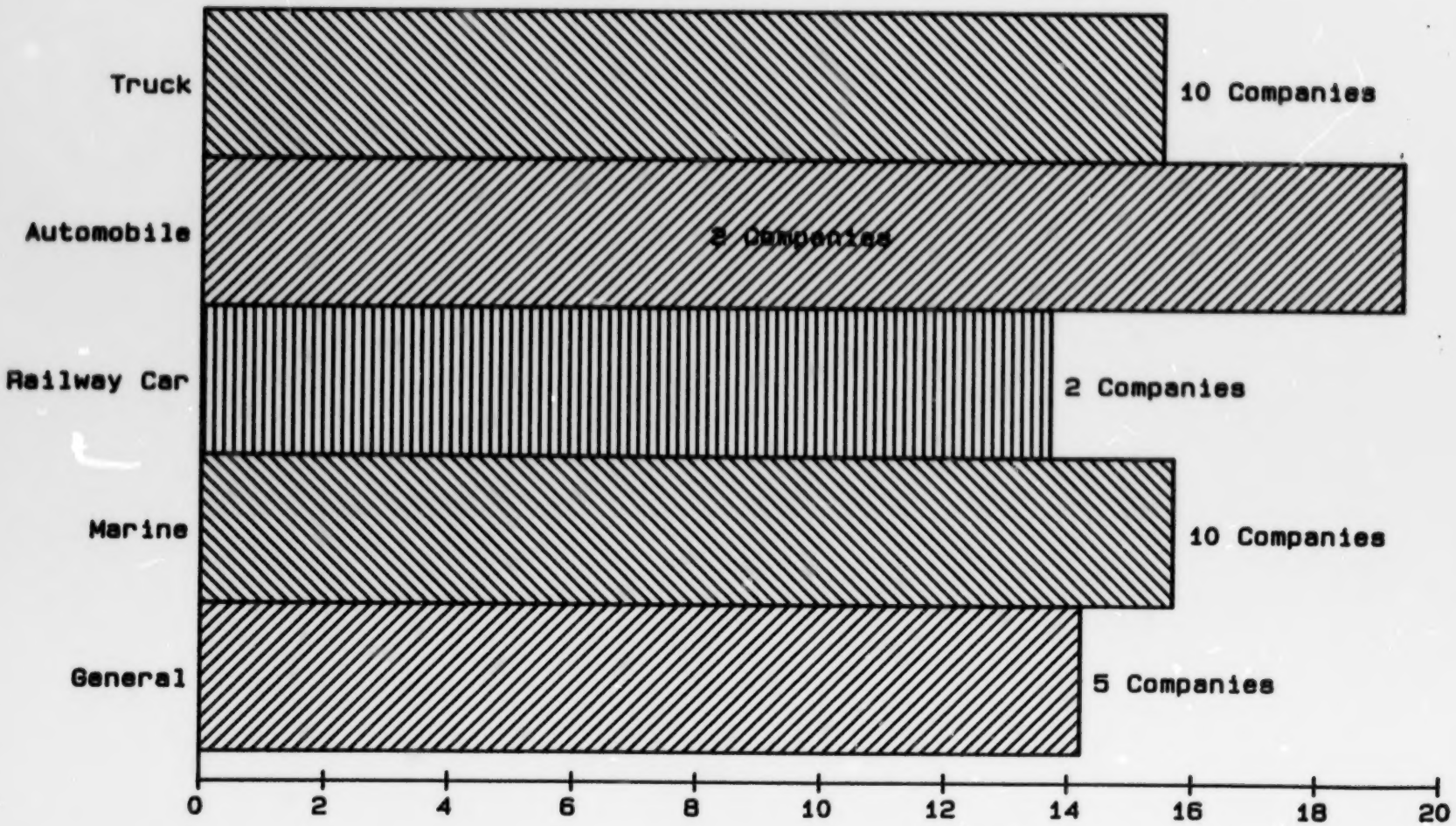

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Fig.4 - Awareness of Welding Research Organizations (by region)

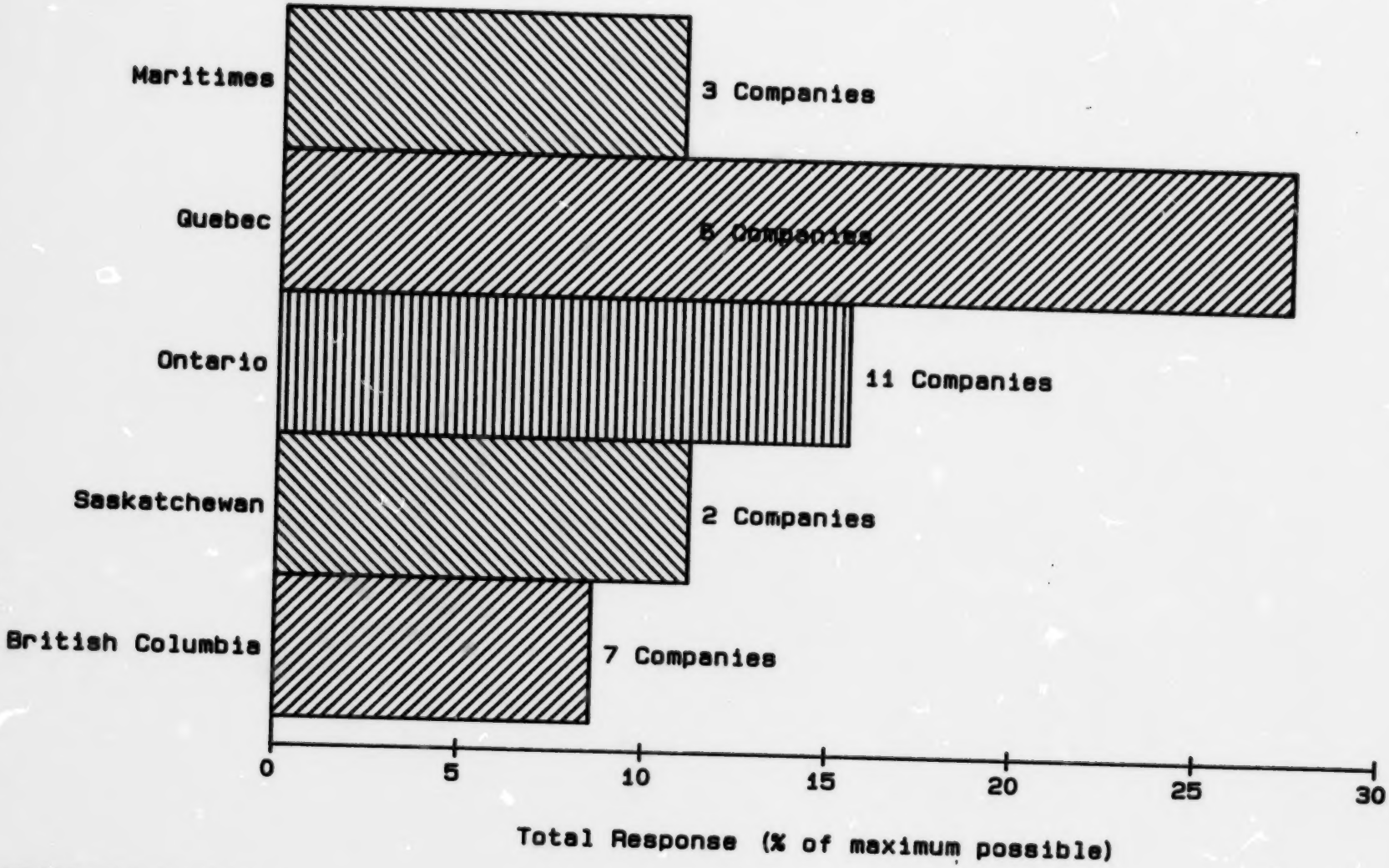

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Fig.5 - Contact with Welding Research Organizations

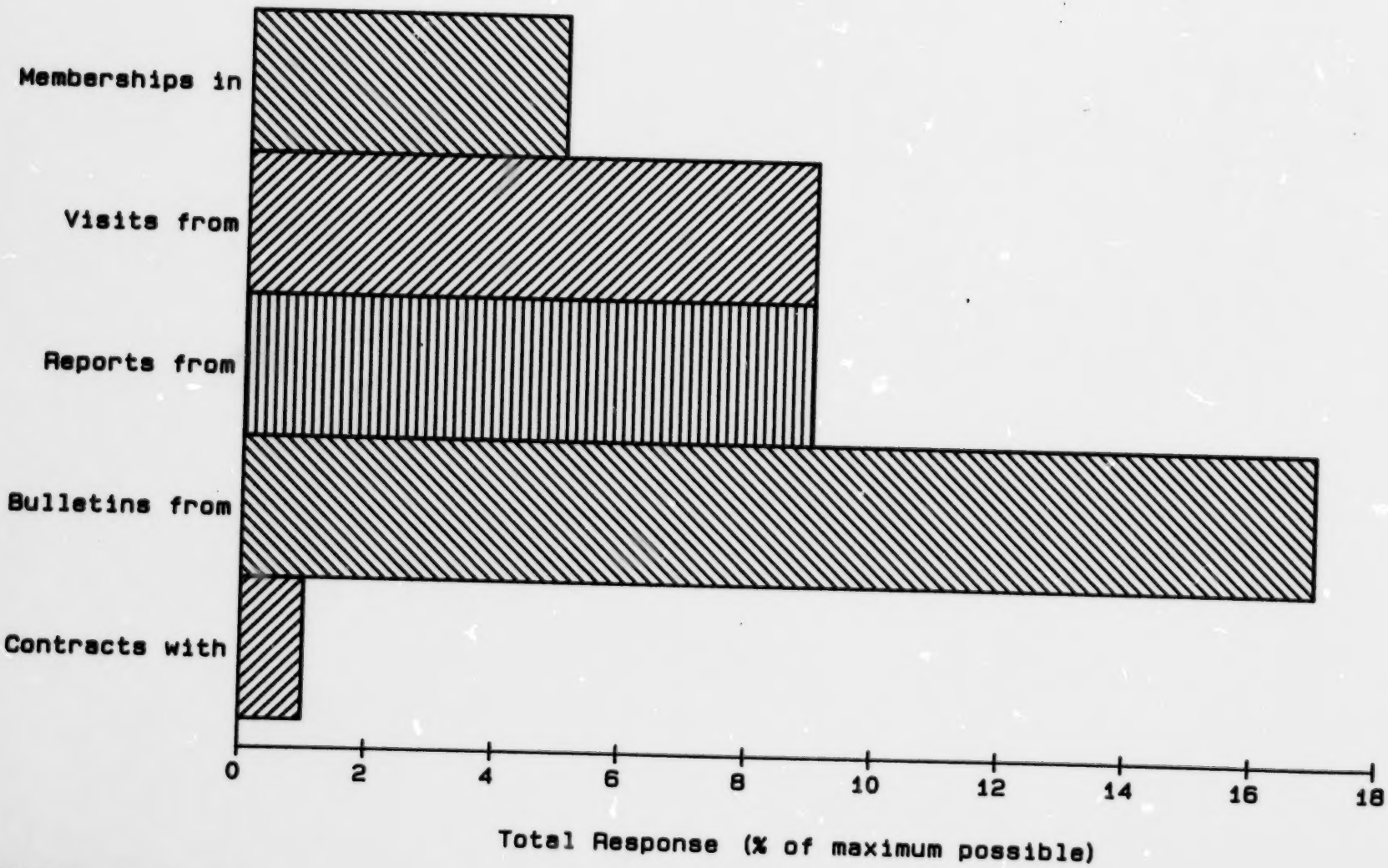

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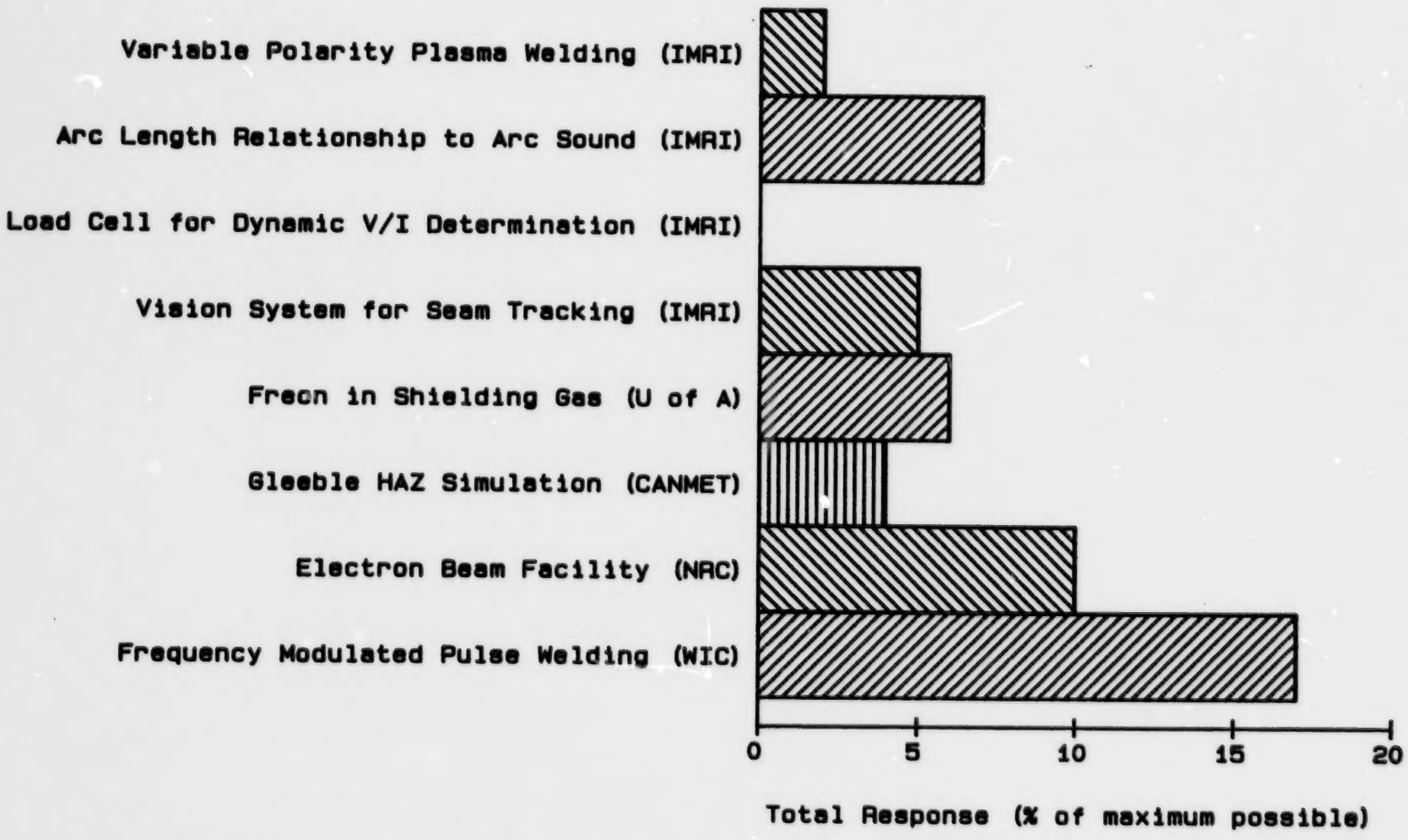
Fig.6 - Awareness of Welding Research Programmes


Variable Polarity Plasma Welding (IMRI)
Arc Length Relationship to Arc Sound (IMRI)
Load Cell for Dynamic V/I Determination (IMRI)
Vision System for Seam Tracking (IMRI)
Freon in Shielding Gas (U of A)
Gleeble HAZ Simulation (CANMET)
Electron Beam Facility (NRC)
Frequency Modulated Pulse Welding (WIC)
0
5
10
15
20
Total Response (% of maximum possible)

TB/CT-REG.B21615-1

Fig.7 - Awareness of Welding Research Programmes (by industry)

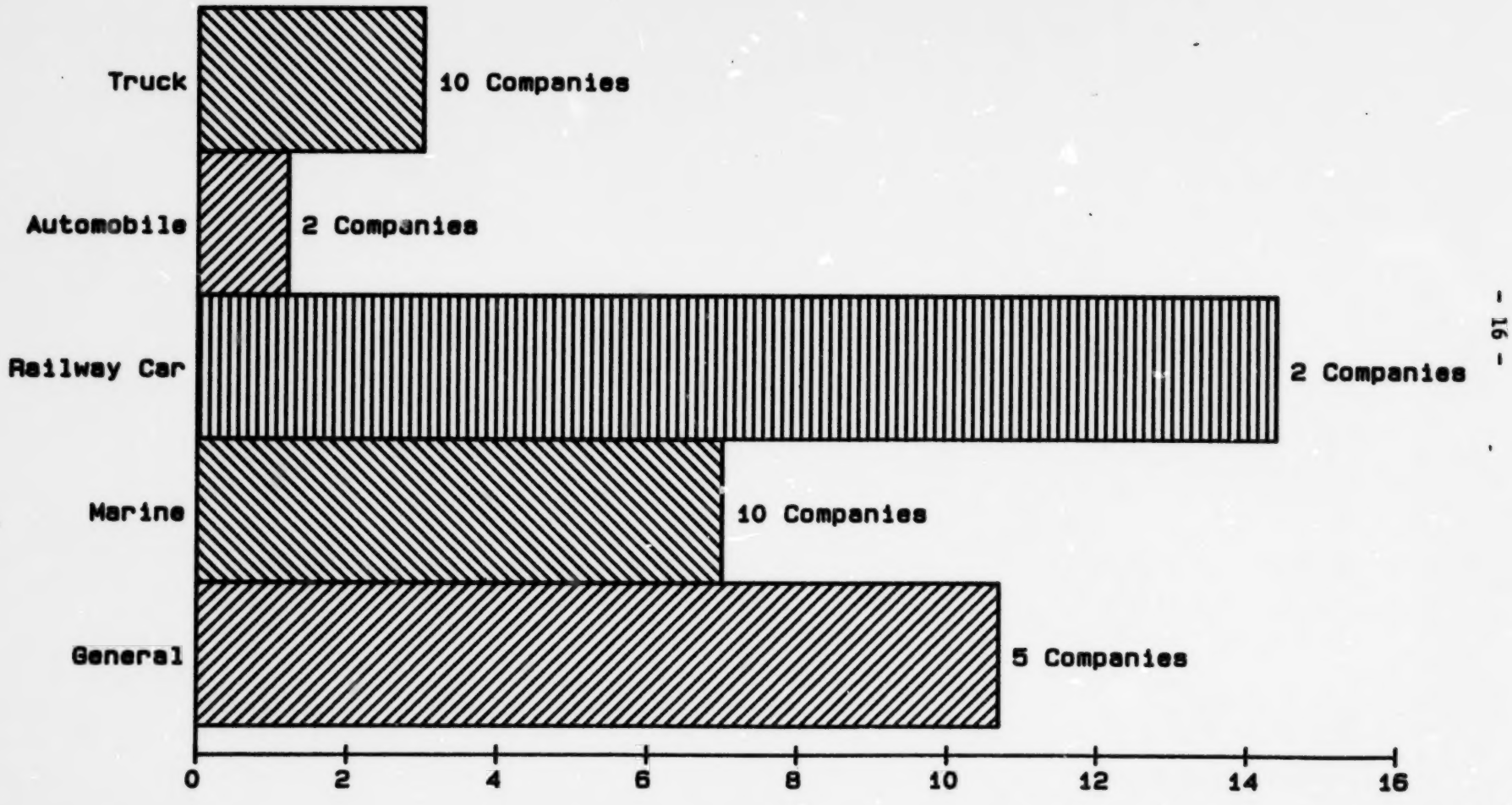


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Fig.8 - Awareness of Welding Research Programmes (by region)

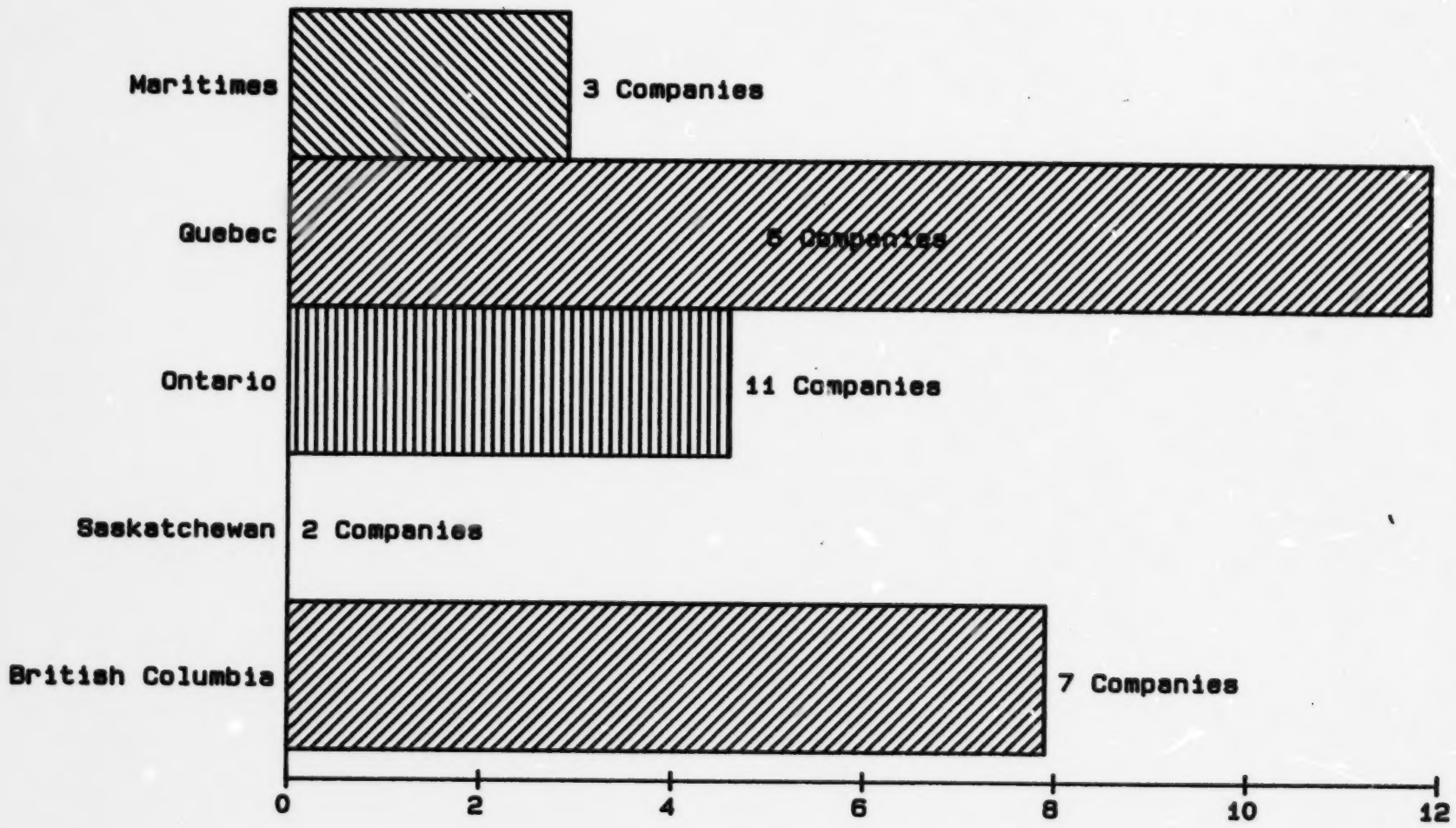

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Fig.9 - Commonest Aluminum Welding Problems

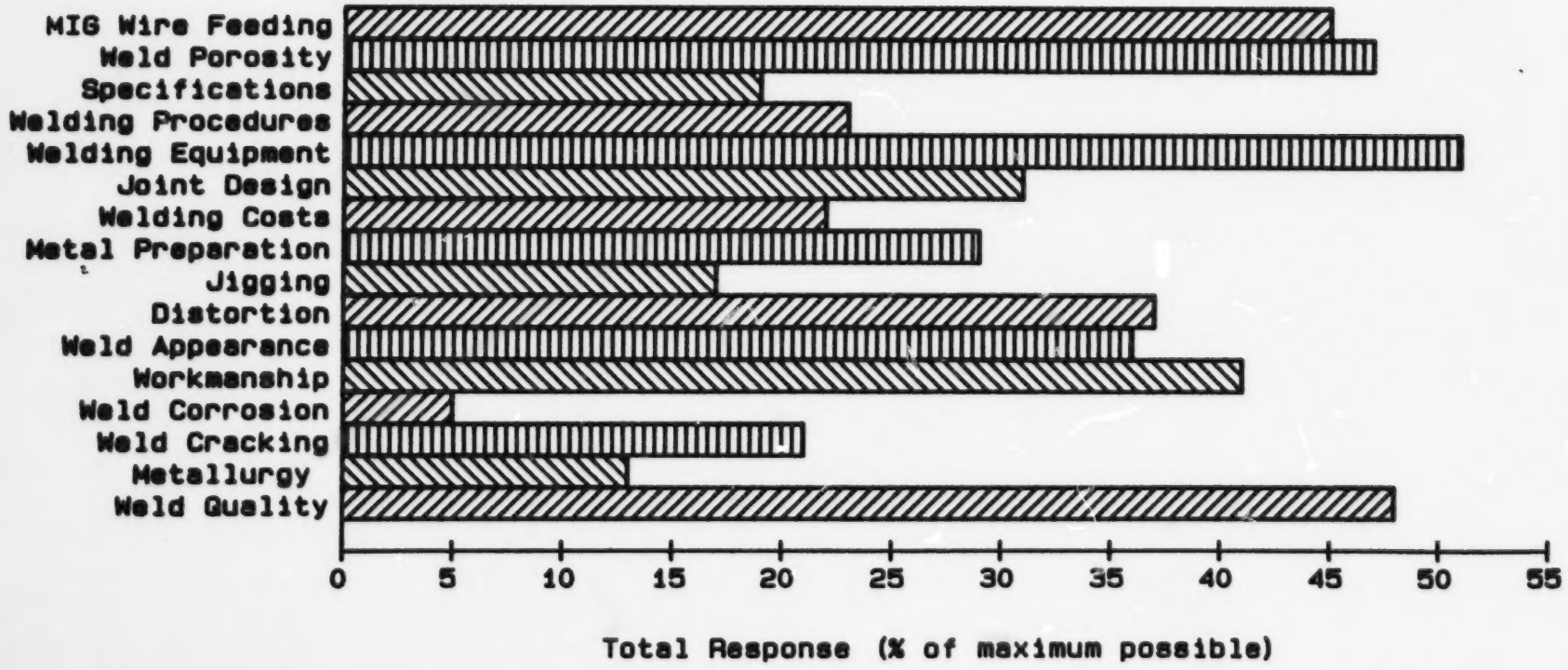

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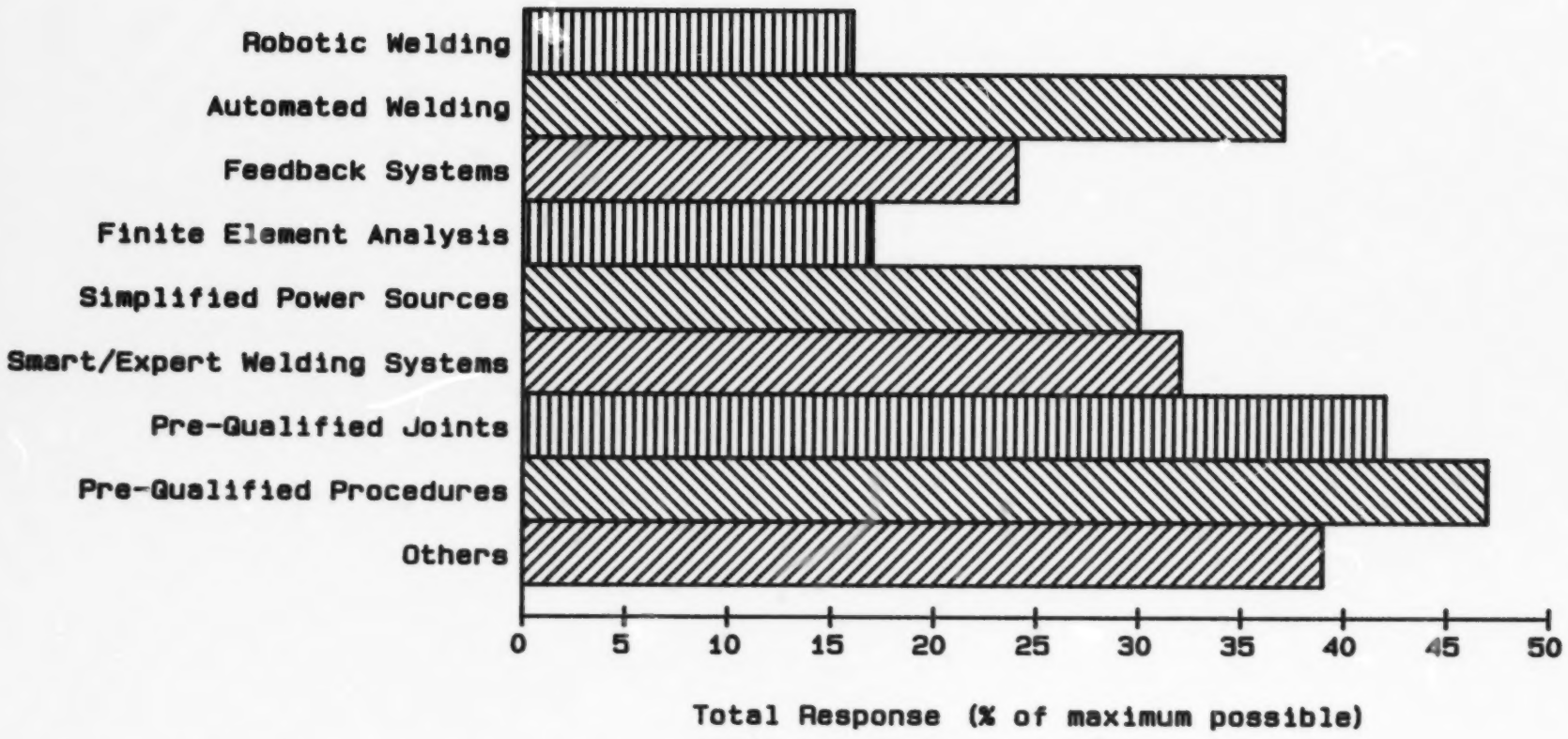
Fig.10 - Welding Technology Needing Research



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APPENDIX A

COMPANIES SURVEYED

APPENDIX A

Companies Surveyed

Company	Phone
Advance Engineered Products Ltd., 144 Henderson Drive, Regina, Sask S4N 5P7	(306) 924-0900
Allied Shipbuilders Ltd., 1870 Harbour Road, North Vancouver, B.C. V7H 1A1	(604) 929-2365
Almac Industries Ltd., 12285 April Street, Montreal, Que H1B 5L8	(514) 645-2221
Bedarco McGruer Inc., 5730 Place Turcot, Montreal, Que H4C 1V8	(514) 933-7551
Bombardier Inc., PO Box 580, La Pocatiere, Que G0R 1Z0	(418) 856-1232
Crockett McConnell Inc., PO Box 500, Bridgewater, N.S. B4V 2X6	(902) 543-9100
Dorr-Oliver Canada Limited, 174 West St., South, Orillia, Ont L3V 6L4	(705) 325-6181
Ebco Industries Ltd., 7851 Alderbridge Way, Richmond, B.C. V6X 2A4	(604) 278-5578
Fabricated Steel Products, 850 Division Road, Windsor, Ont N9A 6P7	(519) 969-9580
Fairview Industries Ltd., PO Box 924, Armdale PO, Halifax, N.S. B3L 4K9	(902) 876-2325
Fathom Oceanology Limited, 6760 Campobello Road, Mississauga, Ont L5N 2L8	(416) 821-8730
Fruehauf Canada Limited, 2450 Stanfield Road, Mississauga, Ont L4Y 1S3	(416) 277-9511

Companies Surveyed

Company	Phone
Groupe G&G Ltee, 6245 boul. Grandes-Prairies, St-Leonard, Que H1P 1A5	(514) 325-3711
Hike Metal Products Ltd., PO Box 698, Wheatley, Ont N0P 2P0	(519) 825-4691
Hutchinson Industries, 20 Alness Street, North York, Ont M3J 3H4	(416) 661-9330
Indal Technologies Inc., 3570 Hawkestone Road, Mississauga, Ont L5C 2V8	(416) 275-5300
King Equipment Mfg Corp., PO Box 518, 1401 Dundas St., E, Woodstock, Ont N4S 7Z3	(519) 539-6111
L&A Machine Works Ltd., PO Box 134, Fredericton, N.B. E3B 4Y2	(506) 458-1100
Matsumoto Shipyards Ltd., 3829 Dollarton Highway, North Vancouver, B.C. V7G 1A1	(604) 929-3461
National Steel Car Ltd., PO Box 450, Kenilworth Ave., N, Hamilton, Ont L8N 3J4	(416) 544-3311
Remtec Inc., 933 boul. Simard, Chambly, Que J3L 4B7	(514) 658-6671
SKD Mfg Div., SKD Company, 111 St. Arnaud Street, Amherstburg,Ont N9V 2Y6	(519) 736-2141
Shore Boat Builders Ltd., 23511 Dyke Road, Richmond, B.C. V6V 1E3	(604) 524-1341
Surrey Iron Works Ltd., 12294 - 104th Avenue, Surrey, B.C. V3V 3H3	(604) 585-1511

Companies Surveyed

Company	Phone
Technomarine Inc., 598 rue Leclerc, Repentigny, Que J6A 6W6	(514) 585-6114
Trailmobile Group Ltd., 100 Shaver Street, Brantford, Ont N3T 5S2	(519) 758-4335
Versatile Pacific Shipyards Inc., 109 East Esplanade, North Vancouver, B.C. V7L 4J6	(604) 988-2111
West Coast Manly Shipyard, 2150 E. Kent Avenue, Vancouver, B.C. V5P 2T2	(604) 324-7661
Westank-Willock Ind. Ltd., 1155 Park Street, Regina, Sask S4N 4Y8	(306) 525-6741

APPENDIX B

CANADIAN LIGHT METALS FABRICATION INDUSTRY

WELDING RESEARCH SURVEY QUESTIONNAIRE

CANADIAN LIGHT METALS FABRICATION INDUSTRY

WELDING RESEARCH SURVEY QUESTIONNAIRE

INTERVIEW NO. _____ DATE: _____

1.0 Company

1.1 name:

1.2 address:

1.3 phone:

1.4 persons interviewed: position:

1.5 products manufactured:

1.6 number of welders: number qualified for aluminum:

1.7 certified to W47.2? full or limited

1.8 memberships - WIC, EWI, TWI, AWS, WRC, others?

2.0 Product Design

2.1 "in house", purchased, supplied, other?

2.2 drawings prepared by?-

2.3 welding symbols used on all drawings?

3.0 Processes Used

3.1 arc, resistance, solid state, mechanical, adhesive, other?

3.2 MIG, TIG, PAW?

3.3 if MIG - semi-automatic, automatic, robotic, other?

3.4 if TIG or PAW - manual, automatic, robotic, other?

4.0 Welding Personnel

4.1 welders trained "in house", by contract, other?

4.2 welders qualified by?

4.3 qualified welding supervisor employed?

4.4 qualified welding engineer employed?

5.0 Specifications Applied

5.1 - ASME Sect IX, CSA W47.2, S157, S244/W59.2, others?

5.2 - they help or hinder?

5.3 - you participated in their preparation?

5.4 - you use NDT? method?

5.5 - fitness for service is a consideration?

6.0 Information Sources used in the Past	Never	Frequently
6.1 - metal suppliers	0 . . . . 5 10	
6.2 - equipment suppliers	0 . . . . 5 10	
6.3 - universities	0 . . . . 5 10	
6.4 - National Research Council	0 . . . . 5 10	
6.5 - Welding Institute of Canada	0 . . . . 5 10	
6.6 - Aluminum Association	0 . . . . 5 10	
6.7 - other specify	0 . . . . 5 10	

7.0 Awareness of Welding Research Activities	
7.1 - at National Research Council (IMRI)	0 . . . . 5 10
7.2 - at Welding Institute of Canada	0 . . . . 5 10
7.3 - at Ontario Robotic Centre	0 . . . . 5 10
7.4 - at Ontario CAD/CAM Centre	0 . . . . 5 10
7.5 - at University of Toronto	0 . . . . 5 10
7.6 - at Waterloo University	0 . . . . 5 10
7.7 - at Laval University	0 . . . . 5 10
7.8 - University of Alberta	0 . . . . 5 10

8.0 Contact with Welding Research Organizations	None	All
8.1 - memberships	0 . . . . 5 10	
8.2 - visits from	0 . . . . 5 10	

	None					All
8.3 - reports from	0	.	.	5	.	.	10
8.4 - bulletins from	0	.	.	5	.	.	10
8.5 - contracts with	0	.	.	5	.	.	10

8.6 - suggest why there is not more contact?

8.7 - could you benefit from more contact?

8.8 - who should initiate it?

9.0 Awareness of Recent Welding Research Programs	Not Aware					Fully Aware
9.1 - frequency modulated pulse MIG (WIC)	0	.	.	5	.	.	10
9.2 - electron beam welding (NRC)	0	.	.	5	.	.	10
9.3 - Gleeble HAZ simulation (CANMET)	0	.	.	5	.	.	10
9.4 - freon shielding gas for MIG (U of A)	0	.	.	5	.	.	10
9.5 - vision system for seam tracking (IMRI)	0	.	.	5	.	.	10
9.6 - load cell for dynamic V/I determination (IMRI)	0	.	.	5	.	.	10
9.7 - arc length relationship to arc sound (IMRI)	0	.	.	5	.	.	10
9.8 - variable polarity plasma process evaluation (IMRI)	0	.	.	5	.	.	10

10.0 Problems Welding Aluminum in the Past	Never					Frequently
10.1 - related to weld quality	0	.	.	5	.	.	10
10.2 - related to metallurgy	0	.	.	5	.	.	10
10.3 - related to cracking	0	.	.	5	.	.	10
10.4 - related to corrosion	0	.	.	5	.	.	10
10.5 - related to workmanship	0	.	.	5	.	.	10
10.6 - related to appearance	0	.	.	5	.	.	10
10.7 - related to distortion	0	.	.	5	.	.	10
10.8 - related to jigging	0	.	.	5	.	.	10
10.9 - related to metal preparation	0	.	.	5	.	.	10

	Never				Frequently
10.10 - related to welding costs	0	. . . .	5	. . . .	10
10.11 - related to design requirements	0	. . . .	5	. . . .	10
10.12 - related to welding equipment	0	. . . .	5	. . . .	10
10.13 - related to welding procedures	0	. . . .	5	. . . .	10
10.14 - related to specifications	0	. . . .	5	. . . .	10
10.15 - related to porosity	0	. . . .	5	. . . .	10
10.16 - related to MIG wire feeding	0	. . . .	5	. . . .	10

11.0 Technology Needing Welding Research	No				Yes
11.1 - robotic welding	0	. . . .	5	. . . .	10
11.2 - automated welding	0	. . . .	5	. . . .	10
11.3 - feedback systems	0	. . . .	5	. . . .	10
11.4 - finite element analysis	0	. . . .	5	. . . .	10
11.5 - simplified power sources	0	. . . .	5	. . . .	10
11.6 - smart/expert welding systems	0	. . . .	5	. . . .	10
11.7 - pre-qualified joints	0	. . . .	5	. . . .	10
11.8 - pre-qualified procedures	0	. . . .	5	. . . .	10
11.9 - other areas? give details and cite examples	0	. . . .	5	. . . .	10

7/perm/HLS/survey

APPENDIX C

GENERAL SURVEY INFORMATION

APPENDIX C

GENERAL SURVEY INFORMATION

Co. No.	1.5-Prod. Type	1.6-Total Welders	1.6-Alum. Welders	1.7-W47.2 Certif.	1.8-Member-ships	2.1-Prod. Design	2.2-Drwg. Prep'n	2.3-Sym's on Dwgs.	3.1-Joining Process	3.2-Arc Process	3.3-MIG Mode
1	Gen.	20	10	Full	WIC,AWS	In House	In House	Yes	Arc	MIG,TIG	Semi,Auto
2	Truck	125	52	Full	WIC	In House	In House	Partly	Arc,Mech	MIG,TIG	Semi,Auto
3	Truck	200	15	No	None	In House	In House	Yes	Arc, Mech,Adh	MIG,TIG	Semi,Auto
4	Truck	40	23	Full	None	In House	In House	Yes	Arc	MIG	Semi
5	Marine	11	6	Full	WIC,AWS	In House	In House	Yes	Arc	MIG,TIG	Semi
6	Truck	25	8	Full	None	In House	In House	Yes	Arc,Mech	MIG,TIG	Semi,Auto
7	Rail	300	2	No	WIC,AWS	In House	In House	Yes	Arc,Mech	MIG,TIG	Semi,Auto
8	Auto	11	11	No	WIC	Supplied	Supplied	Yes	Arc	MIG	Semi
9	Marine	15	2	Limited	None	In House	In House	No	Arc	MIG,TIG	Semi
10	Auto	55	3	No	None	Supplied	Supplied	Yes	Arc	MIG	Semi
11	Gen.	15	15	Full	None	In House	In House	Partly	Arc,Mech	MIG,TIG	Semi,Auto
12	Truck	7	7	Full	AWS	In House	In House	No	Arc	MIG,TIG	Semi,Auto
13	Truck	40	11	Limited	None	In house	In House	No	Arc	MIG,TIG	Semi
14	Truck	9	3	Limited	WIC,AWS	Supplied	Supplied	Yes	Arc	MIG,TIG	Semi,Auto
15	Truck	40	15	Full	AWS	In House	In House	Yes	Arc	MIG,TIG	Semi,Auto
16	Marine	8	1	Full	WIC	In House	In House	Yes	Arc	MIG,TIG	Semi,Auto
17	Rail	15	40	Full	WIC,AWS	In House	In House	Yes	Arc,Resist	MIG,TIG	Semi,Auto
18	Gen.	25	9	Full	None	In House	In House	Yes	Arc	MIG,TIG	Semi
19	Marine	5	2	Full	None	In House	In House	No	Arc	MIG,TIG	Semi
20	Marine	10	4	Full	AWS	Supplied	In House	Yes	Arc	MIG,TIG	Semi
21	Truck	25	18	No	WIC	In House	In House	Partly	Arc	MIG,TIG	Semi
22	Truck	50	25	Full	WIC,AWS	In House	In House	Yes	Arc	MIG,TIG	Semi,Auto
23	Marine	00	6	Full	WIC,AWS	In House	In House	Yes	Arc	MIG,TIG	Semi,Auto
24	Gen.	75	15	Full	WIC,AWS	Supplied	Supplied	Yes	Arc	MIG,TIG	Semi,Auto
25	Marine	16	16	Full	None	In House	In House	No	Arc	MIG	Semi
26	Gen.	10	3	Full	WIC	In House	In House	Yes	Arc	MIG,TIG	Semi
27	Marine	25	20	Full	None	In House	In House	Yes	Arc	MIG,TIG	Semi,Auto
28	Marine	70	15	Full	None	In House	In House	No	Arc	MIG,TIG	Semi
29	Marine	20	6	Full	WIC	In House	In House	No	Arc	MIG	Semi

APPENDIX C

GENERAL SURVEY INFORMATION (Continued)

Co. No.	3.4-TIG Mode	4.1-Welder Training	4.2-Who Qualifies?	4.3-Qualified Supervisor?	4.4-Qualified Engineer?	5.1-Specs. Applied	5.2-Specs. Beneficial	5.3-Helped Prepare?	5.4-NDT Used?	5.5-Serv. Fit. Important
1	Manual	In House	CWB	Yes	Yes	ASME,W47.2	Yes	No	Yes	Yes
2	Manual	In House	CWB	Yes	Retained	ASME,W47.2	Yes	No	Yes	Yes
3	Manual	In House	Supervisor	No	No	None	N/A	N/A	No	Yes
4	N/A	In House	CWB	Yes	Yes	W47.2	Yes	No	No	Yes
5	Manual	In House	CWB	Yes	Retained	W47.2	???	No	Yes	Yes
6	Manual	In House	CWB	Yes	Yes	ASME,W47.2	Yes	No	Yes	Yes
7	Manual	In House	Supervisor	No	No	None	N/A	N/A	Yes	Yes
8	N/A	In House	Supervisor	No	No	Sae	???	No	Yes	Yes
9	Manual	In House	CWB	Yes	Retained	W47.2	Yes	No	Yes	Yes
10	N/A	In House	Supervisor	No	No	SAE	???	No	No	Yes
11	Manual	In House	CWB	Yes	Yes	W47.2,S244	Yes	No	Yes	Yes
12	Manual	Contract	CWB	Yes	Retained	W47.2	Yes	No	Yes	Yes
13	Manual	In House	CWB	Yes	Yes	W47.2	???	No	Yes	Yes
14	Man,Auto	In House	CWB	Yes	Retained	ASME,W47.2	Yes	No	Yes	Yes
15	Manual	In House	CWB	Yes	Yes	ASME,W47.2	Yes	No	Yes	Yes
16	Manual	In House	CWB	Yes	Retained	W47.2,S244	Yes	No	Yes	Yes
17	Manual	In House	CWB	Yes	Yes	W47.2,S244	Yes	Yes	Yes	Yes
18	Manual	In House	CWB	Yes	Retained	W47.2,S244	Yes	No	Yes	Yes
19	Manual	In House	CWB	Yes	Retained	ASME,W47.2	Yes	No	Yes	Yes
20	Manual	In House	CWB	Yes	Retained	W47.2	Yes	Yes	Yes	Yes
21	Manual	In House	Supervisor	No	No	ASME	Yes	No	Yes	Yes
22	Manual	In House	CWB	Yes	Yes	W47.2	Yes	No	Yes	Yes
23	Manual	In House	CWB	Yes	Retained	W47.2,S244	Yes	No	Yes	Yes
24	Manual	In House	CWB	Yes	Retained	ASME,W47.2	Yes	No	Yes	Yes
25	N/A	In House	CWB	Yes	Retained	W47.2	Yes	Yes	Yes	Yes
26	Manual	In House	CWB	Yes	Yes	W47.2	Yes	No	Yes	Yes
27	Manual	In House	CWB	Yes	Retained	W47.2	Yes	No	Yes	Yes
28	Manual	In House	CWB	Yes	Retained	W47.2,S244	Yes	No	Yes	Yes
29	N/A	In House	CWB	Yes	Retained	W47.2	Yes	No	Yes	Yes

APPENDIX D

TABLE 1

ORGANIZATIONS CONTACTED FOR WELDING INFORMATION

Co. No.	6.1 MtlS	6.2 EquS	6.3 Univ.	6.4 NRC	6.5 WIC	6.6 AA	6.7 Other	Totals
1	10	0	0	0	0	5	4	19
2	2	2	0	0	1	0	0	5
3	2	2	0	0	1	0	0	5
4	0	0	0	0	0	0	0	0
5	2	2	6	0	3	0	0	13
6	2	4	0	0	0	0	0	6
7	5	5	0	0	0	1	0	11
8	0	5	2	0	0	0	0	7
9	0	3	0	0	2	0	0	5
10	2	7	1	0	0	0	0	10
11	5	2	1	0	3	3	0	14
12	3	7	0	0	1	0	8	19
13	3	8	0	0	1	0	0	12
14	3	7	0	0	2	0	7	19
15	3	5	0	1	0	0	2	11
16	4	6	1	1	4	3	3	22
17	7	3	0	0	1	0	0	11
18	5	5	3	5	5	0	5	28
19	5	10	5	5	0	0	5	30
20	10	5	5	0	5	0	5	30
21	0	2	0	0	0	0	0	2
22	2	8	0	1	6	0	0	17
23	5	10	5	0	5	0	0	25
24	0	5	0	0	5	0	3	13
25	0	0	0	0	0	0	0	0
26	5	4	8	3	8	0	4	32
27	4	7	0	0	0	0	0	11
28	10	10	0	0	0	0	0	20
29	0	5	0	0	2	0	0	7
Totals	99	139	37	16	55	12	46	404

TABLE 2

AWARENESS OF WELDING RESEARCH ORGANIZATIONS

Co. No.	7.1 IMRI	7.2 WIC	7.3 ORC	7.4 OCCC	7.5 UofT	7.6 WU	7.7 LU	7.8 UofA	Totals
1	0	10	5	5	1	1	1	1	24
2	0	1	0	0	0	0	0	0	1
3	1	3	0	1	0	0	0	0	5
4	0	5	0	0	0	0	0	0	5
5	1	8	8	4	5	10	0	3	39
6	0	0	2	5	0	0	0	0	7
7	0	0	0	0	0	2	0	0	2
8	0	10	5	8	0	0	0	0	23
9	0	8	2	2	0	0	0	0	12
10	0	1	4	3	0	0	0	0	8
11	1	5	1	0	1	1	0	1	10
12	5	10	2	0	10	10	10	10	57
13	1	5	1	0	0	0	0	0	7
14	0	3	0	0	0	0	0	0	3
15	8	0	1	1	0	0	10	1	21
16	7	10	1	0	0	0	6	0	24
17	5	7	1	0	0	2	3	2	20
18	0	3	0	0	0	0	0	0	3
19	5	5	0	0	0	0	0	3	13
20	0	5	0	0	0	0	0	5	10
21	0	2	0	0	0	0	0	0	2
22	2	10	2	2	0	0	0	0	16
23	0	5	0	0	0	0	0	0	5
24	0	10	0	0	0	0	0	0	10
25	0	0	0	0	0	0	0	0	0
26	0	8	2	0	0	0	0	0	10
27	0	3	0	0	0	0	0	0	3
28	5	3	0	0	0	0	0	2	10
29	3	7	0	0	0	0	0	0	10
Totals	44	147	57	31	17	26	30	28	360

TABLE 3

CONTACT WITH WELDING RESEARCH ORGANIZATIONS

Co. No.	8.1 Mem.	8.2 Vis.	8.3 Rep.	8.4 Bull.	8.5 Contr.	Totals	8.6 Why?	8.7 Bene?	8.8 Who?
1	0	0	0	5	0	5	NO APP.	YES	RES. ORG.
2	0	0	0	5	0	5	"	YES	"
3	0	0	0	0	0	0	"	YES	"
4	0	0	0	0	0	0	"	YES	"
5	2	1	2	2	0	7	"	NO	N.A.
6	0	2	0	0	0	2	"	YES	RES. ORG.
7	3	2	3	3	0	11	"	POSS.	"
8	2	2	2	2	2	10	"	POSS.	"
9	0	0	0	3	0	3	"	YES	"
10	0	0	0	3	0	3	"	PROB.	"
11	0	2	0	0	0	2	"	YES	"
12	0	5	0	5	0	10	"	YES	"
13	0	0	0	0	0	0	"	YES	"
14	0	0	0	0	0	0	"	YES	"
15	0	0	0	0	0	0	"	YES	"
16	2	1	6	0	0	9	"	POSS.	"
17	2	1	3	2	0	8	"	YES	"
18	0	0	0	0	0	0	"	NO	N.A.
19	0	0	2	2	0	4	"	YES	"
20	0	0	0	0	0	0	"	YES	"
21	0	0	0	0	0	0	"	YES	"
22	0	2	0	3	0	5	"	YES	"
23	2	0	0	3	0	5	"	YES	"
24	0	5	5	5	0	15	"	YES	"
25	0	0	0	0	0	0	"	YES	"
26	2	0	0	3	0	5	"	YES	"
27	0	0	0	0	0	0	"	YES	"
28	0	0	0	0	0	0	"	YES	"
29	0	3	2	2	0	7	"	YES	"
Totals	15	26	25	48	2	116			

TABLE 4

AWARENESS OF WELDING RESEARCH PROGRAMMES

Co. No.	9.1 FMP	9.2 EB	9.3 Gleeb	9.4 Freon	9.5 Seam	9.6 V/I	9.7 Sound	9.8 VPP	Totals
1	2	0	0	0	0	0	5	0	7
2	4	0	0	0	0	0	0	0	4
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	4	4
6	0	0	0	0	0	0	0	0	0
7	1	1	0	0	0	0	0	0	2
8	0	0	0	2	0	0	0	0	2
9	5	2	0	0	0	0	0	0	7
10	0	0	0	0	0	0	0	0	0
11	3	4	5	0	0	0	1	1	14
12	0	0	0	3	0	0	10	0	13
13	2	0	0	0	0	0	0	0	2
14	0	0	0	0	0	0	0	0	0
15	0	5	0	0	0	0	0	0	5
16	0	8	0	2	6	0	0	0	16
17	8	0	3	0	7	0	3	0	21
18	0	2	0	0	0	0	0	0	2
19	0	0	0	0	0	0	0	0	0
20	5	0	0	0	0	0	0	0	5
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	5	0	5	5	2	0	0	0	17
24	10	5	0	5	0	0	0	0	20
25	3	0	0	0	0	0	0	0	3
26	0	0	0	0	0	0	0	0	0
27	2	2	0	0	0	0	0	0	4
28	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0
Totals	50	29	13	17	15	0	19	5	148

TABLE 5

COMMONEST ALUMINUM WELDING PROBLEMS

Co. No.	10.1 Qual	10.2 Metal	10.3 Crack	10.4 Corr	10.5 Work	10.6 Appear	10.7 Dist	10.8 Jig	10.9 Prep	10.10 Cost	10.11 Design	10.12 Equip	10.13 Proced	10.14 Spec	10.15 Poros	10.16 WFeed	Totals
1	5	0	0	0	5	3	0	0	3	0	5	0	0	0	3	0	24
2	7	0	1	0	6	6	2	0	5	1	3	2	0	0	5	5	43
3	0	0	0	0	2	2	0	0	0	0	3	6	0	0	2	5	22
4	0	0	0	0	2	2	0	0	0	0	3	6	0	0	2	5	20
5	10	5	3	4	6	6	9	1	3	1	10	6	0	0	10	0	74
6	2	0	2	0	3	3	3	1	3	0	0	3	0	0	2	3	25
7	5	0	0	0	5	5	1	0	1	3	2	2	0	0	5	4	33
8	0	0	0	0	2	2	5	5	0	0	4	3	2	0	2	1	26
9	5	2	2	0	3	3	2	1	2	0	0	4	3	0	6	1	34
10	5	0	4	0	5	7	1	2	0	4	0	8	0	0	2	2	38
11	3	1	2	1	5	4	4	1	1	1	0	3	1	5	4	4	38
12	8	3	8	0	8	6	1	0	5	0	2	8	6	0	6	2	63
13	6	4	2	0	3	3	4	1	3	0	2	7	2	1	3	8	49
14	9	2	2	4	3	6	6	1	1	7	2	2	0	1	1	4	51
15	5	6	3	0	3	2	2	1	1	3	3	8	5	5	5	7	59
16	10	0	7	1	5	5	0	10	10	4	5	10	0	8	2	8	105
17	4	3	3	2	3	2	3	2	3	2	2	2	3	0	2	0	36
18	3	0	3	0	4	3	5	0	0	0	0	7	4	0	4	7	40
19	1	1	2	0	1	0	3	1	3	5	0	1	1	1	5	2	27
20	5	3	0	0	7	7	7	7	7	10	5	7	5	5	10	10	95
21	5	0	2	0	5	2	2	0	0	0	0	0	0	0	3	10	29
22	3	0	2	0	3	2	0	0	0	0	1	5	0	0	0	0	16
23	5	0	0	0	3	2	5	5	4	0	5	2	5	8	8	5	57
24	10	0	5	0	5	5	5	0	5	10	10	10	10	8	10	10	103
25	0	0	0	0	0	0	0	0	0	0	0	7	0	0	3	3	13
26	3	2	4	0	3	5	9	3	8	6	8	8	3	6	9	5	82
27	10	2	2	0	5	5	8	2	7	3	9	10	3	2	10	8	86
28	2	2	1	0	4	2	1	2	1	0	1	7	2	2	2	7	36
29	9	2	2	2	9	5	8	2	7	5	5	4	3	2	9	5	79
Totals	40	38	62	14	118	105	106	48	83	65	90	148	68	54	135	131	1405

TABLE 6

WELDING TECHNOLOGY NEEDING RESEARCH

Co. No.	11.1 Robot	11.2 Auto	11.3 FBack	11.4 FEA	11.5 SPS	11.6 SEWS	11.7 PQJts	11.8 PQProc	11.9 Other	Totals
1	0	0	0	0	0	2	10	10	5	27
2	0	0	0	0	5	5	0	0	0	10
3	0	4	0	3	6	1	0	5	0	19
4	0	4	0	3	6	1	0	5	0	19
5	7	6	3	3	3	0	0	0	7	29
6	0	2	0	0	0	5	0	0	6	13
7	0	5	5	10	3	4	0	0	8	35
8	5	7	7	0	2	4	0	0	0	25
9	0	5	5	5	0	0	0	0	10	25
10	7	1	7	0	0	1	0	0	0	16
11	1	0	3	3	7	7	9	9	4	43
12	6	10	2	10	0	5	0	0	0	33
13	3	7	0	0	5	5	6	6	10	42
14	3	10	0	0	0	0	3	7	4	27
15	7	5	5	3	5	8	8	8	8	57
16	7	7	7	9	9	5	3	3	0	50
17	0	0	0	0	5	10	10	10	10	45
18	0	2	0	0	0	0	10	10	5	27
19	0	1	0	0	3	0	0	0	0	4
20	0	0	0	0	7	0	7	7	6	27
21	0	5	0	0	0	0	5	5	4	19
22	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	8	5	5	5	5	28
24	0	10	10	0	0	10	10	10	7	57
25	0	6	7	0	0	7	8	8	0	36
26	0	5	0	0	5	0	7	7	4	28
27	0	4	8	0	4	9	9	9	3	46
28	0	0	0	0	0	0	10	10	4	24
29	0	0	0	0	5	0	1	1	4	11
Totals	46	106	69	49	88	94	121	135	114	822

APPENDIX E

RESPONSES TO QUESTION NO. 11.9

APPENDIX E

RESPONSES TO QUESTION NO. 11.9

(1) Four companies indicated that with the MIG process the smoke (fume) is a problem and they would welcome a simple system of catching it at the source without interfering with the inert gas shield. One added the desire to see the 5xxx series electrode alloys e.g. 5356, weld like 4043 alloy, not only in terms of smoke but also smut and general weldability. In other words the need is for a MIG electrode alloy with the strength and compatibility of 5356 together with the weldability and cleanness of 4043.

(2) Many of the fabricators do most or all of their welding using MIG spool-on-guns. These are all air cooled guns and are rated at 200 amperes under 60% duty cycle. This current level is satisfactory for welding light gauge aluminum but for the heavier gauges the procedures call for somewhat higher currents. Several expressed the wish to have the simplicity, mobility and economy of the spool-on-gun but with the rating increased to about 275 amperes.

(3) The MIG process is by far the most commonly used for aluminum welding. However despite the fact that it is considered a mature process it is still prone to problems and the equipment requires special care and frequent maintenance to ensure quality welding. A look at what might be done to improve its performance and durability was suggested.

(4) One company is convinced by their experiments that mixes of argon and helium shielding gas other than those normally recommended can have benefits for semi-automatic MIG welding of heavy gauge aluminum. They believe some work is indicated to better define these benefits.

(5) Two companies feel that some work should be done to reduce the loss of strength in the weld heat affected zones particularly with the heat treated alloys. They also find hot short cracking to be a problem which is interesting considering that cracking does not seem to be a serious problem generally (see Figure 9).

(6) One company who is fabricating quite sophisticated structures expressed interest in greater development of plasma arc welding of aluminum. However they were not aware of the variable polarity plasma process which might meet their requirements.

(7) Several companies are concerned with health and safety issues when welding aluminum and suggest work should be done to reduce hazards. The cleaning, i.e. degreasing, of aluminum before welding requires the use of chemicals all of which seem to have one or more dangerous properties. Could there not be a study to find a truly safe but practical method of metal degreasing, is their question. A second hazard is the very intense arc light which in a production shop is almost impossible to shield from other workers and in enclosed spaces is reflected by the aluminum so that even the welder must cover himself totally to avoid skin damage. They suggested that some method of containing the light at the arc at least partially would be a

great help. One further hazard mentioned by a road tanker builder is the possibility in an enclosed space of argon gas replacing the air without the welder being aware of the danger. They asked if a "lack of air" sensor and alarm could be devised for this situation.

(8) Weld porosity is probably the single most commonly mentioned problem that fabricators struggle to control. Only one of those surveyed suggested that it be the focus of further study but this is likely a reflection of the general expectation that only by continuous attention to detail can they meet porosity limits. However there is little doubt that even moderate gains in understanding of how to reduce porosity would be welcomed.

(9) Those whose products must meet appearance requirements are aware that after anodizing the welds are always darker than the wrought metal. This difference is reduced somewhat by using a 5xxx series filler alloy rather than the otherwise preferred 4043 alloy but the match is never ideal. One company would like to see a solution to this problem.

(10) One shipbuilder would like to automate, or at least mechanize, the butt welding of the joints in their hulls. This would need some method of seam tracking which could operate in all welding positions and give the operator confidence that he could produce consistently sound welds. Not knowing whether this technology already exists they suggested it could be studied to advantage.

(11) One company feels that much more should be known about the MIG process as used on aluminum. The interactions between power source characteristics, the wire feed system, the arc and the weld pool are known to be very complex which is the main reason why setting absolute welding procedures has not yet been found to be feasible. They suggest that a study of the process fundamentals could make possible the qualification of truly transferable procedures.